Draft Research, Development and Demonstration (RD&D) Plan
Public Interest Energy Research (PIER) Program

Renewable Energy

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I. Renewable Electricity Generation in California

California is often recognized for its diversified electricity generation resources. Of the nearly 58,000 megawatts (MW) of installed electrical generating capacity in the state, over thirty percent (19,330 MW) come from renewable energy resources, with non-hydroelectric resources accounting for 5440 MW (a little less than ten percent of the state's overall capacity). Figure 1a shows the make up of renewable electricity generation capacity in California. Figure 1b shows the quantity of electricity generated by renewable energy sources in California in 1997. In general, renewable energy facilities were responsible for approximately 25 percent of the electricity generated in the state. However, if only small hydroelectric is attributed to renewables generation, the total amount of electricity generated from renewables is 26,906 Gigawatt-hours (or a little of ten percent of the total amount of electricity generated in California in 1997).

Figure 1a: Renewable Electricity Capacity in California (MW)

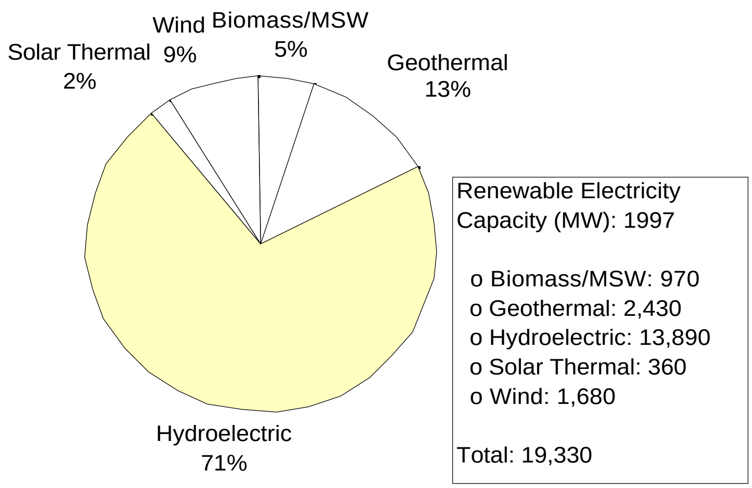
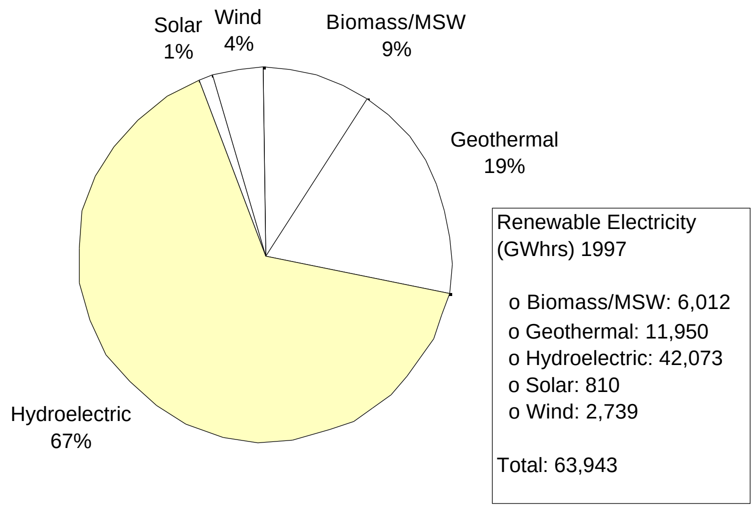


Figure 1b: Renewable Electricity Generated in California (GWhrs/yr)



Hydroelectric facilities, at nearly 14,000 MW, make up the largest component of the renewables capacity. Two thirds of the hydroelectric facilities are located in the Pacific Gas and Electric (PG&E) service territory, over eleven percent in the Southern California Edison (SCE) territory, and nearly ten percent in the Sacramento Municipal Utility District (SMUD) territory. Electricity generated from hydroelectric resources has heretofore been relatively inexpensive, running around 2-3 cents per kilowatt-hour (¢/kwhr). However, as the utilities sell off their hydroelectric facilities at anticipated high book values, the cost of electricity generated from hydroelectric resources is expected to increase.

Geothermal resources account for approximately 2400 MW of generating capacity. Nearly 60 percent of California's geothermal generating capacity is located in the PG&E service territory. Most of the remaining geothermal capacity is located in the SCE service area. Due to changes in drilling techniques and energy conversion systems, the cost of generating electricity from geothermal resources has dropped significantly in the past five years. Cost of electricity generated from currently operating geothermal generating facilities runs between 4-7 ¢/kwhr.

Wind resources make up close to 1700 MW of renewable capacity. Wind generating facilities are split up equally between the PG&E and SCE service territories. Cost of generating electricity from wind facilities can run between 4-7 ¢/kwhr, but for more recent facilities may go as low as 3-4 ¢/kwhr due to special pricing conditions.

Biomass, municipal solid waste (MSW) and biogas (i.e., landfill gas or digestor gas) fueled facilities account for a total of over 970 MW of generating capacity. Of these facilities, biomass direct combustion facilities contribute over 590 MWs, MSW-to-energy facilities make up nearly 170 MWs, and biogas (landfill gas and digestor gas) fueled facilities comprise approximately xx MWs. Nearly two thirds of the biomass/MSW generating facilities are located in the PG&E service territory, the remaining one third in the SCE territory. At present, the cost of generating electricity from biomass or MSW fueled facilities runs between 6-12 ¢/kwhr.

Nearly all of the 370 MW of solar thermal electrical capacity in California developed out of the LUZ parabolic trough projects of the 1980's, and all are located in the SCE service territory. Cost of generating electricity from solar thermal resources runs between 11-13 ¢/kwhr.

It is difficult to assess the total installed capacity of photovoltaic (PV) systems in California as there are a number of small off-grid applications in the state. However, there are approximately five MWs of installed utility-scale systems (e.g., PVUSA, Kerman, etc.). At present, the cost of generating electricity from PV technology runs between 15 to over 30 ¢/kwhr.

II. Issues Facing Renewable Generation in California and Possible Goals

With the exception of hydroelectric facilities, most of the renewable generating capacity in California was built during the 1980's by Independent Power Producers (IPPs) under fixed price contracts required under the Public Utilities Regulatory Policies Act (PURPA) of 1978. Under PURPA, IPPs received electricity prices that rose steadily over a fixed ten year time period for delivered electricity, and capacity prices typically set out over a twenty year timeframe. Prices received under PURPA were based on oil price projections, and were relatively high. When the bottom dropped out of the international oil marketplace in the mid-1980's, electricity generation prices dropped commensurately. A surplus of natural gas, combined with rapid advances in natural gas combined cycle technology, has created an extremely competitive electricity generation marketplace. Currently, prices received for electricity sold in the California Power Exchange are typically 2-3 ¢/kwhr. As a result, the single largest challenge facing most renewable generating technologies is their ability to compete against low cost natural gas generation in a deregulated marketplace. However, renewable energy generation technologies are also being increasingly confronted by environmental issues. Studies linking wind turbines to increases in avian mortality, and of golden eagles in particular, have resulted in an outcry against new wind parks by some members of the environmental community. Similarly, concerns over leakage of a CFC based heat transfer fluid (Monsanto's Therminol VP-1, a biphenyl-diphenyl oxide) at the LUZ facilities brought regulatory scrutiny upon LUZ, and have prompted solar thermal electric technology developers to begin looking at other heat transfer mediums and fluids. Lastly, developers of both biomass and geothermal generating facilities are being forced to consider more carefully disposal of residues generating by the facilities due to more stringent regulations and increased concerns aired by the environmental community.

Based on comments and suggestions collected from Focus Group meetings held in late 1997 and early 1998, California Energy Commission (CEC) staff identified issues facing renewable energy technologies, and possible technical goals for resolving these issues which can be addressed by RD&D. In addition, CEC staff, in combination with comments from the Public Interest Energy Research (PIER) Policy Advisory Council categorized the issues into high level issues facing renewable electricity generation technologies in California. Each high level issue is listed below, along with prioritized technical goals. Appendix A (not presented in this draft) describes the manner in which the technical goals were prioritized.

A. Cost Competitiveness: It is important to reduce the cost of renewable energy systems to improve their value as part of the overall electricity system and sustainability.

Although renewable energy technologies have a wide variety of capital and operating costs, most renewables are not currently cost competitive in a deregulated electricity market. To be market competitive, research and development is needed to lower capital costs, improve conversion efficiency and reduce O&M costs. In addition, R&D efforts *should take into account opportunities for renewables to be competitive in niche markets as a way of eventually working their way into a position of broad market competitiveness. Goals for resolving the cost competitiveness issue include:*

1) High capital costs of renewable energy systems make it difficult for renewables to compete in a deregulated electricity marketplace and should be reduced.

2) Reduced O&M costs are needed to help improve the cost competitiveness of renewable energy systems.

3) Improvements in efficiency are critical to increasing electricity generation production at reduced capital and operating costs.

4) Renewable energy systems should be designed or marketed to receive economic rewards for non-energy benefits they provide.

B. Reliability and Dispatchability: Renewable energy systems should develop reliability and dispatchability capabilities that enhance their value as an energy resource.

With some exceptions, such as hydroelectric systems, renewable electricity generation systems lack the same degree of reliability and dispatchability as existing fossil fueled generation systems. This lack of high reliability and dispatchabilty prevents renewables from being competitive in California's deregulated electricity marketplace. RD&D efforts should focus on improving reliability and dispatchability of renewable systems (e.g., perhaps through development of lower cost storage capabilities) that will enhance the value and competitiveness of renewables as an energy resource in a deregulated electricity marketplace. Goals for resolving reliability and dispatchability issues include:

1) There is a need for lower cost technologies (e.g., such as low cost storage) for renewable energy systems that increase their dispatchability capabilities closer to that provided by fossil fueled generators.

2) Renewable energy system designs must be developed that allow the systems to load follow effectively or to provide peak power economically.

3) There is a need to develop O&M techniques or processes that will improve the reliability of renewable energy systems

4) Hybrid renewable energy systems developed for California must have reliability and dispatchability capabilities comparable to fossil fueled electricity generators.

5) Project demonstrations are needed to establish a track record of reliability for renewable technologies emerging from conceptual RD&D.

6) Resource assessment models which are needed to accurately and inexpensively predict resource availability are outdated, and impact the overall reliability of renewable energy systems.

C. Power Quality and Safety: Improvements in power quality, dispatchability and safety control features will help alleviate concerns associated with the tie-in of a number of distributed renewable energy systems into California's grid system.

R*enewable energy technologies are good candidates for distributed energy generation, and yet, there are concerns regarding possible impacts of renewable systems on the safety* *and power quality within distribution lines. In addition, the inability to dispatch them on command has limited their acceptance as distributed generation resources. RD&D efforts should be directed to developing improved control over power quality and dispatchability of distributed renewable energy systems, and safety features that isolate or prevent downstream electrical safety problems. Goals for improving power quality and safety issues include:*

1) There is a lack of standardized interfaces with utilities and energy service providers to allow efficient and safe dispatchability of renewable energy systems.

2) There is a need to develop and demonstrate control systems that provide for a high level of power quality from hybridized renewable energy systems.

3) There is a lack of methodologies to assess and improve the strategic value of renewable energy systems deployed for electricity generation.

4) Improvements in safety features are needed to increase the broad based market acceptability of renewable energy systems

D. Waste Utilization: Renewable electricity generators in California may be under-utilizing wastes as an energy resource.

To date, only clean agricultural and forest residues have been used to any extent for electricity generation in California. Most residues and wastes are viewed as a waste disposal problem rather than fuels for renewable energy generation. There is limited information on the use, environmental impacts and economics of wastes as feedstocks for energy generation and for production of value-added products. In addition, only limited work has been done to examine the potential to improve combustion and power production using co-firing techniques. RD&D efforts should focus on ways to use existing wastes as a renewable energy feedstock in an environmentally beneficial manner, and on co-firing techniques will help resolve waste disposal issues while simultaneously shifting some of the costs away from electrical customers. Goals to improving waste utilization by renewable energy technologies include:

1) There is insufficient information on how to use wastes as a renewable energy feedstock cost-effectively and in an environmentally beneficial manner.

2) There is a lack of information on how renewable energy systems can receive economic rewards for using wastes as an energy resource from beneficiaries other than electricity ratepayers.

3) There is a need to demonstrate at the pilot-scale or larger level, renewable energy systems that use waste materials as an energy resource in a cost competitive and environmentally acceptable manner.

4) There should be a consistent systems analysis approach on renewable energy systems that takes into account full resource cycle impacts and benefits, and which quantify these in monetary values to the extent possible.

E. Non-Energy Benefits: Renewable energy systems will benefit by improving their ability to integrate into existing environments or structures, and by being rewarded economically for providing non-energy benefits in addition to their energy value.

The ability of an energy technology to integrate unobtrusively into a consumer's existing environment is important to its marketability. In addition, marketability of an energy technology is enhanced if the technology provides value in addition to its energy related benefits. Most renewable energy technologies stand out from their existing environment, leaving a noticeable footprint or difference in appearance. Few renewable energy technologies are rewarded economically for providing non-energy benefits to the marketplace. Some, like roof top integrated photovoltaic systems, integrate more seamlessly into the existing structure, and provide a non-energy benefit by both acting as the rooftop and prolonging the life of the rooftop substructure. R&D efforts should focus on ways to make renewable energy technologies integrate better with existing structures, and to enhance those features that can result in economic rewards for both energy and non-energy benefits. Goals for improving ways in which renewable energy technologies can be better integrated into existing environments and increase their ability to be rewarded for providing non-energy benefits include:

1) There is a need for renewable energy system designs that integrate into existing environments or structures to increase their aesthetic appeal, and which also increases the non-energy value of the system (e.g., PV/roofing integrated systems).

2) There is a need to develop renewable energy systems that can provide a market competitive return on investment based on their combined energy and non-energy (i.e., value added) benefits

F. Innovation: Renewable energy advancements may occur in areas unexpected by the current R&D community, or market conditions may change in such a manner as to drive R&D into new areas.

It is important to maintain the capability to provide R&D funding in the renewables areas for innovative advancements that move in directions not anticipated at this time. In addition, flexibility in renewables R&D funding should be maintained to allow for unexpected changes in market conditions.

III. Future Renewable Electricity Generation in California

A. Overall Objectives

One of the purposes of the PIER Program is to help fund public interest energy RD&D that will provide benefits to California's electricity customers. In particular, as set forth in the PIER Strategic Plan developed by stakeholders in 1997, projects funded under PIER should help make California's electricity more affordable, cleaner, reliable and secure. Consequently, it is helpful to have a concept of what California's renewable electricity industry should be like in the future to better understand how to direct PIER funding in renewables appropriately.

Sometime soon after the end of the transition period (i.e., by the year 2003), renewable energy technologies should be ready to sustain a competitive position in California's electricity generation marketplace. This does not mean renewable energy generation technologies will necessarily have to generate electricity at the same cost as natural gas generation technologies. However, it will require renewables to provide the same, if not a higher, level of value to electricity customers than natural gas generation technologies. In particular, renewables are likely to be evaluated for value based on their cost, reliability, power quality, dispatchability, environmental benefit, ease of installation and use, appearance, and other non-energy benefits. Desirable qualities for renewable generation technologies in each of these areas are as follows:

1) *Cost*: Currently, costs of generating electricity make up less than 30 percent of the electricity bill paid by customers. Consequently, renewable generating costs do not necessarily have to be as low as those from natural gas fired generating technologies. However, those renewables that do not provide other overriding value will probably have to stay within 50 percent of the current Cost Of Electricity (COE) of natural gas fired technologies (i.e., no more than 4-5 ¢/kwhr) to be acceptable (as electricity suppliers only) to most consumers.*

2) *Reliability*: Nearly all electricity customers want the lights to come on when they flip the switch regardless of the source of the electricity. Consequently, to be competitive, renewable generation technologies must provide no less than the same degree of reliability currently provided to electricity customers. For this discussion, reliability is the capability to provide a pre-specified level of power at pre-defined times. Reliability can be specified for the generation technology itself as well as support for the local or overall electrical grid. For individual technologies, this may mean improvements or augmentations in the technology itself to help accomplish high overall capacity factors. Once such example could be the addition of natural gas firing to biomass fueled electricity generation facilities. For other technologies, this may mean adding storage technologies to the baseline technology. Battery storage for photovoltaic (PV) technologies is one such example. Another possible way to increase reliability is by combining technologies that complement the capacity profiles of one another. For example, projects that combine a baseload preferred technology with a peaking preferred technology may provide an effective approach to obtaining high reliability.

3) *Power quality*: If renewable energy technologies, such as rooftop integrated PV, become more widely distributed within the residential and light commercial sectors, power quality is likely to become an especially critical issue for renewables. In particular, it will be important to maintain a certain level of power quality at the user end as well as down stream of the user. As with reliability, power quality levels currently provided to electricity customers will be the minimum targeted level. Power quality will have different target levels depending on where the electricity is generated and used. For example, electricity generated by renewables for direct feed into the grid will have to meet utility grade power quality specifications. Electricity generated for direct use by a user will have to potentially meet both specifications of the utility as well as potentially more strict requirements of the user.

4) *Dispatchability:* The capability to bring generation resources on and off line quickly and efficiently could be increasingly important in the future if peak loads grow in California. As part of the grid, renewables that can be rapidly dispatched to provide local voltage support will be highly valued. For smaller, and very distributed renewable generation resources, increased dispatchability may mean improved electronic interfaces, as well as changes in the design of the technology itself. For larger renewable resources, improved dispatchability may be accomplished through hybridization (e.g., with natural gas).

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* Note: For a typical residential bill of $200/month, a 50% increase in COE causes an overall 13% increase in the total bill, which is equal to approximately $26 more per month.

5) *Environmental benefits:* One of the drivers to renewable energy generation in the past has been its perceived cleanliness, and is likely to continue to be an important value-added component for renewable energy technologies. In particular, renewable electricity generation has become synonymous with “green power,” and a number of electricity customers have demonstrated a willingness to pay a premium for what they consider to be “clean and green” power. However, to retain their perception as a clean electricity resource, renewables must achieve emissions equal to, if not lower, than those from natural gas combined cycle technologies. Similarly, renewable generation sources may have to demonstrate some clear environmental benefit not provided by other competing generation technologies.

6) *Ease of installation and use:* Electricity customers who are considering renewable energy generation for onsite needs want not only reliable systems, but relatively simple and easy to operate systems. The bench mark most customers will use to measure the ease of installation and use will be natural gas fired generation, where start up and shut down consists largely of hitting a switch. Renewable energy systems that are easily installed and relatively simple to operate will be more valued than complex systems requiring frequent customer interaction.

7) *Appearance:* Concerns voiced over the aesthetics of roof mounted solar water heaters, as well as wind turbine parks, have demonstrated that renewable generation technologies will not be immune to appearance considerations. Consequently, increased value will be given to systems that integrate well into the existing environment or structure in which they are being placed.

8) *Non-energy benefits:* Renewable generation systems can have non-energy impacts that provide benefits to others. For example, biomass generation facilities that use forest residues as fuel potentially help reduce wild fires that can threaten property damage as well as lives. Similarly, these same facilities help reduce air pollution associated with the uncontrolled release of large amounts of particulate matter, carbon monoxide, etc. when a wild fire occurs. Renewable energy generation technologies that can capture these “external” benefits and have them paid for by the beneficiaries will not only significantly increase their capability to be sustainable, but will also concretely demonstrate their public benefit value. In a competitive marketplace, the value of a product is typically assessed using measures like return on investment (ROI). Where possible, renewable generation technologies should employ ROI like measures to provide a quantifiable assessment of the value of the combined energy and non-energy benefits which can be gauged against other possible investments.

B. Renewables in the Near, Mid and Long Term

1) Biomass/MSW

a) Near Term Outlook (2003)

Biomass and municipal solid waste to energy facilities comprise over 970 megawatts of electrical generating capacity in California. Approximately 590 megawatts of this capacity comes from thirty-three direct combustion facilities employing fluidized bed or spreader stoker technologies. Industry representatives indicate the cost of electricity (COE) for these existing facilities is over $0.07 per kilowatt-hour. Nearly all the existing facilities are expected to survive the transition to a competitive generation marketplace with financial support being provided under the Existing Renewables Trust Account. However, to be sustainable in the period following the transition, facilities employing existing technologies will have to significantly reduce costs or develop additional income streams. Consequently, RD&D work in support of existing biomass direct combustion technologies will focus on techniques or processes which lower costs or helps develop value added income streams, are easily adaptable to existing technologies, and can be applied before the year 2003. If successful, this proposed RD&D work will benefit California's biomass energy industry by helping ensure sustainability of 590 MWs of existing direct combustion facilities. However, biomass facilities prevent air pollution emissions associated with open field burning of agricultural residues, provide alternatives to landfill disposal of urban woodwastes, and provide jobs and taxes in the more economically hard hit rural areas of California. Consequently, the proposed RD&D work also provides public benefits to a number of California electricity customers located in rural or forested areas of the state.

Thirty-five existing landfill gas to energy facilities and eleven digestor gas to energy facilities provide over 240 megawatts of installed generating capacity in California. Most of these facilities use reciprocating engines to generate electricity, some employ gas turbines, and a few use steam boiler and steam turbine technology. As with direct combustion biomass facilities, the COE from landfill and digestor gas to energy systems is higher than current PX prices. Consequently, lowering costs or developing value added income streams are the highest priority RD&D work to help support sustainability of existing landfill gas to energy technologies. Similarly, products generated by this near term RD&D work should be available before the year 2003, and be readily adaptable to existing landfill and digestor gas technologies.

b) Mid Term Outlook (2007)

By the year 2007, pre-deregulation direct combustion facilities still in operation will have found ways to lower costs, increase efficiencies, generate revenues in addition to those resulting from electricity sales, and increase use of waste materials. Due to increases in efficiencies, the total capacity of pre-deregulation direct combustion facilities is expected to increase slightly above 1999 levels.

In response to the economics associated with a competitive electricity marketplace, two new classes of direct combustion biomass-fueled power plants may also begin emerging into the marketplace by 2007: small-scale (i.e., < 5 MW) facilities, and large-scale (i.e., > 25 MW) power plants. In general, the small-scale power plants will not be as efficient or economical as the large facilities, but will have greater dispatchability and can be constructed and sited much more quickly. Growth in small scale facilities will be primarily based on a demand for distributed generation resources that defer more expensive T&D expansions or upgrades in areas that also have biomass waste disposal issues. Growth of the larger scale biomass facilities will be primarily in response to localized demand for voltage support, and occur in rural/agricultural areas or border on heavily forested areas. In either location, the larger facilities will likely be sited close to existing agricultural chemical processing facilities that can serve as a consumer of value added products generated by the facilities. Overall, it is expected that there will be a growth of approximately 50 to 100 MW of new small-scale facilities and 75 MW of new and larger scale facilities in California; bringing the total capacity of direct combustion biomass power plants to over 750 MW by 2007.

Developments in landfill gas to energy will also see the emergence of two new landfill gas to energy technologies by 2007: above ground reactors, and landfills used as the reactor. Above ground reactor technologies will develop in response to requirements that municipalities recycle fifty percent of the municipal solid waste stream by the year 2005. As a result, above ground reactor technologies will focus on cost competitive ways to optimize the generation of useful products from the waste stream. These products may include solid "composting" products from aerobic processes, solid "soil amendment" products from anaerobic processes, and electricity generation from combustion of the biogas. In addition, above ground reactor developments will be tied to emergence of more efficient and clean energy conversion systems, such as fuel cells. Where landfills are used as the reactor, advancements will occur in response to the desire to obtain better decomposition of landfilled wastes, and to make landfill gas recovery and utilization more cost effective. Consequently, improvements in using landfills as the reactor will focus on methods to control the biochemical processes occurring in landfills, reduce decomposition times, achieve better landfill gas recovery rates, and prevent ground water pollution. Due to the regulatory drivers, and the advancements in technology, over 200 MW of new landfill gas to energy capacity are expected to appear in California by 2007.

Improvements in digestor gas technology will be based on increasing concerns over ground water contamination associated with current land disposal methods of animal wastes, increasing pressure to capture global climate change gases (primarily methane), and the commensurately higher costs of compliance. In response, industry will develop lower cost methods for treatment, capture and conversion of the resulting "biogas," while simultaneously developing new value added products beyond electricity generation. There is anticpated to be a modest growth in digestor gas to energy projects representing less than 50 MW of new capacity by 2007.

c) Long Term Outlook (2011)

By 2011, the new class of small scale and larger scale direct combustion technologies will have fully emerged. The larger scale systems should be cost competitive in the deregulated electricity marketplace, be capable of handling a variety of waste materials, provide high strategic value to the grid, generate high value products in addition to electricity, and receive economic gain for contributing non-energy benefits to the community. Small-scale systems will not be economically competitive in the open market, but will be cost effective in niche markets, primarily in the industrial agricultural sector. For both classes of direct combustion technology, the systems will provide a cost effective alternative to landfill disposal of woody type wastes (e.g., urban, agricultural and forestry residues), and will have air emissions on par with equivalently sized natural gas fired systems.

Small scale thermal gasification systems firing gas turbines or other prime movers will also have fully emerged as distributed generation resources in California. They should have efficiencies comparable to competing fossil fired generation facilities, be capable of using a variety of woody wastes as fuels, be rapidly dispatched, and provide high power quality to the grid.

A variety of energy conversion systems for use on digestor gas and landfill gas facilities will have been developed by 2011 including fuel cells, advanced micro-turbines and Stirling engines. Commercially available digestor gas systems will provide a cost effective way to dispose of animal wastes, while simultaneously providing electricity and thermal energy for use on-site, as well as value added products such as soil amendments and fertilizers. Both above and below ground (i.e., the landfill as the reactor) landfill gas to energy systems will be fully commercial. Due to revenues generated from receipt of organic wastes and production of valuable byproducts, in combination with high efficiency energy conversion systems, electricity generated from landfill gas to energy facilities is expected to be among the lowest cost electricity in California's grid.

2) Geothermal

a) Near Term Outlook (2003)

Geothermal energy (natural heat from the Earth's crust) conversion facilities amount to more than 2400 MW of installed capacity in California. In the past four decades, commercial development of geothermal energy has focused on tapping hydrothermal resources. These resources occur in a variety of forms (those containing hot water and/or steam), each requiring advances in technology to ensure attainment of optimal benefits. Over 50 geothermal power plants are being operated in the state employing conventional dry steam, flashed steam and binary cycle technologies. These plants operate at high capacity factors (70% –100%) and typically have availability factors of 95 percent. These geothermal power plants produce clean and environmentally benign power and require very little land. Cost of generating electricity from these energy conversion facilities ranges from as low as 4 cents/kwh up to 8 cents/kwh, depending on resource characteristics.

Given the pressure of competition under California's deregulated electricity market, further development of the state's enormous geothermal resource is uncertain. Most of the existing facilities are expected to survive the transition under a competitive and deregulated marketplace. The financial support from AB 1890's Renewable Transition Fund, will help support retention of some of these facilities. To help enhance the competitiveness of the existing facilities there should be a considerable reduction in operating and maintenance (O&M) costs. Expansion of the existing resource and development of new fields that are likely to be discovered will require reduction in the costs of drilling and completing geothermal wells. Reservoir management should be enhanced and additional revenue streams should be added such as minerals recovery. In addition, if the true value of benefits and avoided costs of using geothermal energy and its removal of market inequities in the deregulated marketplace is realized, the demand for geothermal energy may increase. Dispatchability of geothermal power plants can be increased by the introduction of geothermal/natural gas hybrid projects.

By 2003, the competitiveness of geothermal energy is expected to be enhanced by lowering the risks and associated costs of developing geothermal resources. These costs will be lowered by finding improvements in the ways to reduce the costs of exploration, drilling and completing geothermal wells; improving the understanding of basic geological conditions associated with hydrothermal systems; and enhancing reservoir management. The cost of producing geothermal power must be reduced further if the full potential of this clean resource is to be realized. In addition, other sources of revenues should be developed (e.g., value-added products, mineral recovery, cascaded use of heat). If successful, the above RD&D works will benefit the California's geothermal industry by helping ensure the construction of over 600 MW geothermal power plants.

b) Mid Term Outlook (2007)

By the year 2007, developmental efforts to enhance the competitiveness of geothermal energy production in the deregulated marketplace is expected to reduce costs of drilling and completing geothermal wells from between 5 to 10 percent lower than 2003 costs, and to lower O&M costs of power plants by 15 to 20 percent. Understanding of basic geological conditions associated with hydrothermal systems will have increased. There will be further improvements in the technologies for exploration, detection of fracture and permeable zones, well siting, fluid production and fluid injection. Extraction technology has already begun for producing energy from enhanced geothermal systems. New generation of binary geothermal turbines with improved thermodynamic efficiency with advanced heat rejection systems and with considerable reduction in equipment and construction costs has already emerged. Furthermore, by the year 2007, geothermal facilities with multiple income streams from generation of value added products will be demonstrated in the emerging green energy markets. New geothermal fields (such as in Glass Mountain, Surprise Valley, and others) will have been discovered and have begun generating power as a result of preceding development efforts .

c) Long Term Outlook (2011)

A majority of the country's and California's geothermal resource exists in rocks that are hot but lack sufficient porosity, permeability, or fluid to produce geothermal fluids in economic quantities. By the year 2011, through creative and collaborative partnerships of diverse stakeholders will emerge a new technological advance in drilling technology. An increase in accuracy of mapping deep, permeable zones in hydrothermal zones will be realized. Technology to extract energy from resources of progressively lower permeability and fluid content will be economically developed. A new generation of geothermal turbines with improved thermodynamic efficiency integrated with multiple sources of revenues will be economically competitive in the open market.

3) Hydroelectric

Due to uncertainties associated with changes in ownership of existing hydroelectric facilities, and the environmental community's concerns over construction of any new hydroelectric facilities in California, CEC staff are not able to determine the direction hydroelectric technologies will take in the near, mid or long term. At present, CEC staff are proposing a market assessment of hydroelectric potential in California to better understand what role hydroelectric facilities are likely to play in the deregulated electricity marketplace, and better understand how advances in hydroelectric technology may impact that role.

4) Photovoltaic

a) Near Term Outlook (2003)

Dramatic changes have occurred in utility industry perceptions about the nature of the domestic PV grid-connected market. Several years ago, the best market appeared to be in megawatt-scale applications. Today the emphasis is on rooftop and building integrated systems. SMUD was an early force in this shift with its PV Pioneer Program. The Los Angeles Department of Water and Power and the City of Alameda offer other "green electricity" programs in California. The California Emerging Renewables Buydown Program will pay up to 50 percent of capital cost but no more than $3/W for a system that offsets customer load.

Other programs such as the federal Million Solar Roofs (one million PV and solar thermal rooftop installations by the year 2010) and the UtilityPhotoVoltaic

(UPVG) Group's TEAM-UP initiatives are developing the installation and service infrastructure and increasing demand. RD&D efforts to reduce module and balance of system costs have the potential to rapidly dovetail in to installation initiatives by providing lower manufacturing costs and higher efficiency in modules.

A recognition of the potential for building-integrated PV has existed for some time as exemplified by the U.S. DOE's PV:BONUS (Building Opportunities in the United States for Photovoltaics) and European and Japanese programs. The Japanese programs are especially aggressive with 15,000 residential installations in the current fiscal year.

b) Mid Term Outlook (2007)

By 2007, crystalline silicon and semicrystalline silicon module technology will have matured. Thin film module development opportunities will still exist with respect to improved efficiency and reduced cost. Economies of scale in manufacturing will have been achieved as individual plant output exceeds 50 MW/year. Power conditioner units will be reliable and will cost less than $ 0.3/W even for small (e.g., residential) systems.

Technical and institutional issues associated with the penetration of dispersed rooftop PV will be only partly resolved. The intermittent nature of PV generation will be overcome by a number of strategies including pooling at the neighborhood level, integration with cost effective storage, such as flywheels, ultracapacitors and batteries, and integration with fossil fuel-based fuel cells, microturbines and internal combustion engines. These systems will provide premium power and peak shaving. The cost effectiveness of PV may be determined by the degree to which non-energy benefits are recognized and internalized.

c) Long Term Outlook (2011)

By 2011, innovations will lead to concentrator PV arrays as competitive as flat plate arrays. Concentrators will be able to provide both electricity and thermal energy thereby increasing the value of PV in commercial and industrial installations.

5) Solar Thermal Electric

a) Near Term Outlook (2003)

California is home to approximately 370 MWs of solar thermal electric facilities, of which 360 MWs is made up of parabolic trough technology developed in the 1980's by LUZ. An additional 10 MWs of thermal solar electric capacity comes from power tower (central receiver) technology embodied in the Solar Two project. Both parabolic trough and power tower technologies represent central station systems. A third solar thermal electric technology under development in California is dish engine systems, which represent a distributed generation application.

Current costs for generating electricity from parabolic trough systems are in the range of 10¢ – 13¢/kwh depending on plant configuration. Plants at this cost range are presently viable only in special overseas markets using the World Bank's Global Environment Facility (GEF) financing and/or special incentives which have been made available by certain nations.[1] In the near term to 2003, parabolic trough projects will be built to incorporate incremental technology improvements based on lessons learned since the last trough projects were built in California during the late 1980's. A COE of about 10 ¢/kwh will result from this work.

Presently, power tower technology is in the engineering prototype stage of development. As such, existing costs are significantly above market competitive levels. Success in preparing power tower (central receiver) technology for competitive markets depends on building collaborations with California industry, the US Department of Energy and its national laboratories, and on using international collaborations and international market opportunities. California corporate experience in designing, operating, improving and maintaining the Solar Two project is the foundation upon which such collaborations can begin.

The two advantages of central receiver technology are its potentially low levelized energy costs and high solar-only capacity factors, up to 65 percent. However, full realization of these attributes is not likely to occur until after the 2011 timeframe.

Near-term development activities in power tower technology will likely focus on continued support and completion of the 10 MW Solar Two project. Solar Two is a proof of concept central receiver plant, about one-tenth the size of a commercial-scale plant. The purpose of project is to demonstrate the use of industrial-grade salt (a molten mixture of potassium and sodium nitrates) as an efficient heat collection and thermal energy storage fluid in a solar-only central receiver plant. The molten salt central receiver system provides high pressure/high temperature steam for increased turbine efficiency and lower cost compared to the water steam system employed at the earlier Solar One facility. Thermal energy storage for plant operation after sundown is highly efficient, on the order of 99 percent. In the process of its shakedown and early operation, several RD&D tasks were also identified and performed in order to solve the types of design and construction issues typical when a new technology is first built. The plant currently operates as a prototype utility central station providing power to the grid.

A series of design and build steps and incremental improvements will be required to reduce the market's perception of risk and to scale up central receiver technology to a commercial level. An 18 cent/kwh near-term levelized energy cost can be reached at Solar Two by upgrading the seventeen year-old Solar One field and field control system to current state of the art technology, upgrading the first generation molten salt receiver, and by providing a full complement of salt for the energy storage system. The resulting Solar 2000 represents the second proposed near-term RD&D endeavor for central receivers. Solar 2000 will provide the hard data necessary for the confident design and construction of mid-term projects.

Dish engine technology comprises a broad definition of parabolic reflective dishes providing solar energy to a heat engine. The concentrated solar radiation is absorbed by the receiver and then transferred to the engine. In general, two main categories of heat engines (i.e., those involving Brayton and Stirling cycles) are actively considered for use in dish engine systems. Of these two main engine types,

[1] On January 1, 1999 a new Spanish solar law took effect which states that 25 cents/kwh will be paid for solar power from plants of up to 50 MW in size. The plants do not have to be solar only; if the plant is hybrid, the 25 cent rate applies to the solar electricity fraction. Spain now has a market incentive equivalent to that which LUZ had in California during the 1980s.

only the Stirling cycle engine has reached a fully operational demonstration phase. However, both dish Stirling and dish Brayton systems are in the engineering development stage and face a number of technical and economic hurdles before they reach commercial status. Current costs of dish Stirling engine systems are relatively high, exceeding 20 ¢/kwh.

A major near term goal for dish Stirling engine developers is the successful commercialization of a Stirling engine for non-solar purposes, but which has the capability to be used for solar dish applications. Difficulties in engine development in the past and the inability to capitalize as yet on economy of scale considerations from a mass manufactured engine has delayed the progressive development and introduction of this technology into the California energy market. However, it is expected that a commercially viable Stirling engine will be market ready by 2003. Similarly, advances in dish concentrator and receiver/engine technologies are anticipated to double the annual efficiency of dish Stirling systems by 2003 to the mid-twenty percent levels. Overall, while Stirling engine technology may have begun moving into the commercial realm by 2003, dish concentrator and receiver technologies will still be in the prototype engineering stage of development. Lastly, near term research efforts are expected to result in an engineering prototype of a hybridized dish solar system by 2003. When compared with central energy generation power plants under current pricing structures, dishes cannot compete as electricity only resources even if the most optimistic goals are reached. However, optimized hybridization can increase the market potential for dishes when a capacity resources criterion is used. Benefits of hybridization over solar only operation include increases in generation, distribution and transmission capacities as well as improved reliability.

b) Mid Term Outlook (2007)

By 2007, a number of improvements in parabolic trough technology will have helped move the technology much closer to a commercial status. In particular, the concentrator structure will be re-engineered based on new materials and manufacturing techniques, thereby improving performance and cost. In addition, the field will be better optimized to minimize heat loss and to improve the match of the field to the Rankine EPGS, while field performance will be improved through development of better maintenance and alignment equipment. These next generation improvements are expected to reduce the cost of trough power by 2007 to 7- 8¢/kwh, a cost range which should allow parabolic trough technology to compete in selected emerging green markets.

Dish engine developments by 2007 are expected to result in design, cost reduction and efficiency improvements in concentrator drives and heatpipes to further reduce the capital cost to $3400/kW for a hybridized receiver. In addition, research work on Stirling engines will produce a prototype modular sized dish Stirling system (possibly 1 kW) for potential promotion in end-use applications similar to those available in the photovoltaic marketplace.

c) Long Term Outlook (2011)

For parabolic trough technology, additional technology development and cost reductions will be necessary in the longer-term (i.e., 2011) to achieve cost reductions to below 6 ¢/kwh. The key to higher efficiency performance will be to raise the temperature of the solar field by using direct steam generation in the heat collection element of the concentrator, or to develop a synthetic heat transfer fluid which will remain a stable liquid at higher temperatures.

By 2011, heat-pipe, heat receiver, concentrator and Stirling engine technologies are expected to be approaching maturity. Optimized plant size for modular installations would remain at about 50 MW. Capital costs for hybrid dish Stirling units would be $1800/kW with the potential to drop as low as $1000/kW. Investigation of volumetric receivers for both Brayton cycle and Stirling engine dishes will be underway.

6) Wind

a) Near Term Outlook (2003)

Wind farms contribute nearly 1700 MWs of generating capacity to California's electrical system. Improvements in turbine efficiency and reliability, along with increased competition associated with deregulation, are resulting in refurbishment of many of California's wind systems. In general, the refurbishments represent a move towards taller, larger turbines (i.e., greater than 500 kilowatts of capacity) with increased reliability and decreased O&M costs. By the year 2003, it is expected that over sixty percent of California's existing wind systems will be refurbished in this manner.

Concurrent with refurbishment of existing wind farms, the industry will also be developing improved ways to compete at deregulated electricity prices. Among these efforts will be the development of wind forecasting models that predict wind conditions and wind park performance for the following day on an hourly basis, development of low cost storage technologies suitable for utility-scale wind turbine systems, creation and implementation of improved power electronics, and development of hybrid wind systems. Lastly, prototypes of a low cost wind turbine with a COE of approximately 3.5 ¢/kwhr is expected to be developed and ready for field testing.

California's utility-scale wind industry will be primarily focusing in the near term on how best to compete in a deregulated marketplace against inexpensive natural gas fired technologies. Conversely, small-scale wind turbine (i.e., wind turbines less than 40 kilowatts in capacity) efforts are expected to converge on increasing small wind turbine competitiveness in green power niche markets. These efforts will include development of lower cost turbines with improved performance and which are easier and safer to install, as well as inexpensive predictive resource assessment models.

b) Mid Term Outlook (2007)

By 2007, utility-scale wind turbines capable of generating electricity at 2.5 ¢/kwhr will be emerging into California's generation marketplace. Similarly, low cost storage technologies, the development of wind hybrid systems, and reliable wind forecasting systems will have increased wind's dispatchability such that it will begin playing a significant role in providing reliable capacity to the grid. Similarly, changes in turbine design, operation and placement will have virtually eliminated avian mortality. Wind turbine developers will begin conducting performance tests to determine ways to extend performance of the low cost turbine to marginally windy areas, and to establish the ability of the turbine system to achieve international standards for safety and performance.

Small-scale wind turbines circa 2007 will have firmly established their role in the green power market. Most of the small wind applications will revolve around providing clean energy in rural and semi-rural areas where connections to the grid are cost prohibitive. Wind turbine developers will continue to look for ways to lower costs through improved designs and manufacturing operations, including hybridization with fossil or other renewable energy technologies. At the same time, development efforts will include establishment of control systems that will monitor performance of the wind turbine system, and make automatic adjustments to retain high performance, reliability and safety.

c) Long Term Outlook (2011)

Utility-scale wind systems should be openly competitive in California's deregulated electricity marketplace by 2011. Due to development of accurate wind forecasting methods, low cost storage, advanced power electronics and integrated hybridized operation, these systems will also have a high degree of dispatchability and reliability. The systems will produce no or little noise, and be designed to integrate well into the surrounding environment.

By 2011, small-scale wind turbines should be available as robust, off-the-shelf items from a number of distributors. Systems will include low cost power electronics for automated performance monitoring and control, and be capable of hybridization with other electricity resources to maintain electricity production during times of no or low wind speeds.

IV. The Strategic Role of PIER Funding in Renewables RD&D

A. Funding Efforts Outside the Energy Commission

Due to the limited amount of funding available through PIER, it is necessary to use PIER funds in conjunction with other funding efforts, and in a manner which will provide the greatest benefit to California electricity customers. Renewable energy RD&D is currently conducted by a number of public and private entities, including national labs, universities, technology developers and manufacturers of electrical generation systems. Table 1 (at this time only biomass work being conducted by national labs is provided as an example) is a listing of the Renewable Energy RD&D efforts currently being conducted by a number of public sector parties. Where possible, PIER funding will be used strategically with other RD&D efforts to address high priority issues, and to help accelerate progress of the technology towards the commercial marketplace. In general, PIER renewable RD&D joint funding efforts will emphasize collaborative agreements where large-scale public interest RD&D in renewables is being undertaken, or where another governmental agency such as the Department of Energy has taken a lead role in development of a renewable energy technology which corresponds to the CEC's direction in the technology. Competitively bid Requests for Proposals (RFPs) will be used for joint funding of renewable energy RD&D for smaller projects, or where private industry has taken a lead role in development of a technology.

Table 1a: National Lab RD&D Work in Renewables

Technology Area	Ames NL	Idaho (INEEL)	Lawrence Berkeley NL	Lawrence Livermore NL	Oak Ridge NL
Biomass	**Biorenewable Resources Program**: Work on thermal gasification; especially measurement and reduction of alkali components. Emphasis on co-firing with coal. ***Robert C. Brown***, Section Leader (515) 294-3758 rcbrown@iastate.edu	No work in biomass	**Energy Conversion and Storage Program**: Work on synthetic fuels (including biomass) from thermal gasification. ***Elton J. Cairns***, Program Head (510) 486-5028 EJCairns@lbl.gov	**Energy Programs**: Work on conversion of municipal solid waste to hydrogen; primarily for transporation purposes. ***Terry Surles***, Associate Director (925) 422-9863 surles1@llnl.org	**Energy Efficiency & Renewable Energy Program**: Extensive work in biofuels development (for chemical, fuel and electricity generation). ***Anthony C. Schaffhauser***, Director (423) 574-4826 acs@ornl.gov

B. Existing Renewable Energy RD&D Projects Funded Under PIER

To date, the Energy Commission has provided nearly $11.4 million in funding to renewable energy RD&D projects under PIER. Table 2 provides a summary listing of renewable energy RD&D projects funded under PIER by technology type.

Table 2: Renewable Energy RD&D Projects Funded Under PIER

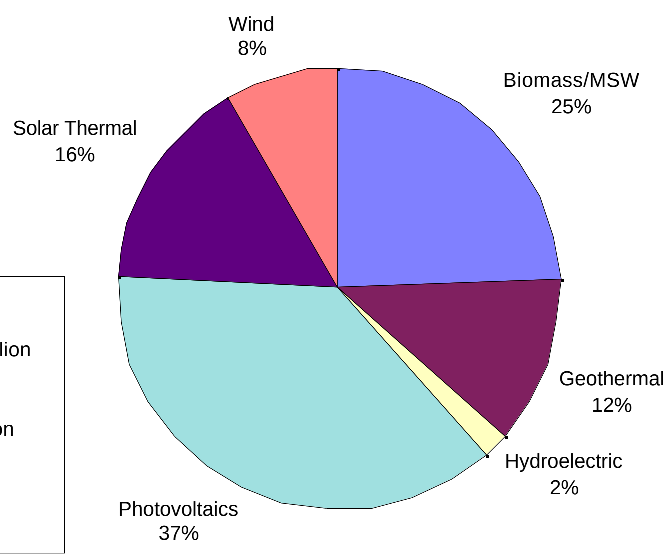
Technology Type	***Company Name***	***Project Title***	***Amount Awarded***
Biomass/MSW	Gas Research Institute	Natural Gas Cofiring in Biomass Fueled Boilers	$655,702
	Energy and Environmental Research Corporation	Utilization of Waste Renewable Fuels in Boilers with Minimization of Pollutant Emissions	$981,952
	Collins Pine Company	Collins Pine Company/BCI Cogeneration Project	$1,148,961
Geothermal	Electromagnetic Instruments	Development of an Extended Logging Tool for Geothermal Exploration and Field Development	$1,380,709
Hydroelectric	PowerWheel Associates	PowerWheel Demonstration	$200,000
Photovoltaics	SDG&E	PV Chargeport Demonstration	$90,000
	SCE	Photovoltaics Development	$1,000,000
	PowerLight Corporation	Powertherm Product Development	$542,362
	Utility Power Group	Residential Electric Power Security	$426,343
	EDTEK	Hybrid Solar-Fossil Thermophotovoltaics	$867,945
	PowerLight Corporation	Powerguard California Manufacturing	$958,991
	SMUD	PVUSA Power Conditioning Unit Test Center	$374,847
Solar	Berquam Energy Systems	Design and Optimization of a Solar Fired 2E Absoption Chiller	$150,000
	SCE	Solar Dish/Stirling	$430,000
	SCE	Solar Two	$1,200,000
Wind	The Wind Turbine Company	The Next Generation Turbine Development Project	$950,000
Total:			$11,357,812

V. Filling the RD&D Gaps

A. Existing PIER Funding and Overview of Near Term Funding Strategies

To date, the Energy Commission has awarded over $11.3 million in RD&D funds through the PIER Program for renewable energy projects. Figure 2 depicts the current breakout of PIER funding in renewables by renewable energy category. The PIER awards shown in Figure 2 were made over a series of three PIER solicitations: a Transistion Solicitation held at the very beginning of the PIER Program in 1997, a First General PIER solicitation held in early 1998, and a Second General PIER Solicitation held in the middle of 1998. The primary purpose of the Transistion Solicitation was to provide funds for public interest RD&D projects of high merit being funded by California electric utilities, and in jeopardy of being lost during the transition to a deregulated electricity structure. The First General PIER Solicitation was open to any applicant type, but restricted to funding for projects falling in the renewables, energy related environmental research, or environmentally preferred advanced generation program areas. Similarly, the Second General PIER Solicitation was open to any applicant type, but restricted to funding for projects falling in the energy efficiency or strategic energy RD&D program areas. As RD&D plans had not been formulated, there was no concerted strategy in how PIER projects selected for funding under the three solicitations would fit into longer range plans for the technologies, or the needs of the marketplace. However, all three solicitations emphasized selection of projects that would provide high public benefits to California if successful. In the PIER renewable energy RD&D program area, the current intention is to use projects funded to date under the program as a foundation for further RD&D work where feasible.

Figure 2: Current PIER Funding in Renewables RD&D



PIER Funding to date:

- Biomass/MSW: $2.8 million
- Geothermal: $1.4 million
- Hydroelectric: $200,000
- Photovoltaics: $4.3 million
- Solar: $1.8 million
- Wind: $950,000

A number of RD&D activities are being considered in the renewable energy area. The overall goals of the activities are to help retain the significant benefits provided by California’s existing renewable energy industry, and to help establish a sustainable renewable energy industry in California that is market oriented and economically rewarded for both the energy and non-energy benefits provided by the industry. Consequently, the overall strategy to help retain exisitng benefits will be to support RD&D that improves the ability of existing renewable energy technologies to be more competitive in a deregulated electricity marketplace. In addition, there will be support provided for the development of new renewable energy technologies capable of competing in niche markets based on a combination of lower costs, high strategic value to the grid, revenue streams in addition to those provided by electricity sales, and increased value to the customer. Longer term efforts will focus on further development of these new technologies such that they can succesfully and profitably compete in a deregulated electricity marketplace without any governmental support. Tables 3a and 3b are listings of near term renewable energy strategies currently being considered by CEC staff. In general, near term strategies consist of development of analytical tools that cut across the various renewable energy technologies, and a variety of technology development efforts.

Table 3a: Near Term Renewables RD&D: Cross Cutting Analytical Tools

Area	*Issues*	*Focus/Products*	*Funding Mechanism(s)*	
A. Strategic Value Analyses	Lack of understanding of how and where renewables can best meet grid needs for: o T&D deferrals o Voltage support o Reliability	Renewables database and GIS that addresses locations and characteristics of: o greatest need for T&D deferrals o voltage support o reliability o non-energy benefits provided by renewable	Technical assistance contract in R&D Office	Febı
B. Market Assessments	Lack of understanding of the market needs, sizes and economics for renewables in a deregulated electricity marketplace	Market evaluation report that identifies for each renewable technology: o market needs o size of market o market economics	Technical assistance contract	Febı
C. Economic Evaluation Tool	Inability to easily and quickly evaluate the economics of various renewable energy R&D efforts from a profitability perspective	Development of an economic evaluation tool that enables the profitability of renewable energy R&D technology efforts to be assessed	Collaborative or Technical assistance contract	Febı

Table 3b: Near Term Renewables RD&D: Technology Development Activities

Area	*Issues*	*Focus/Products*	*Funding Mechanism(s)*	
A. Biomass/MSW	Existing technologies not competitive. Need to: o reduce O&M o increase efficiencies o develop value added revenue streams	Techniques or processes that lower costs, increase efficiencies or develop value added products, and can be readily adapted to existing direct combustion and landfill gas to energy facilities.	Variety: o Collaborative agmts o Competitive RFPs with industry	o Cc agm o Cc by F
B. Geothermal	Existing technologies not competitive. Need to: o reduce cost of reservoir exploration o reduce drilling costs o develop value added revenue streams	Technologies that: o lower reservoir exploration costs o lower drilling and extraction costs o develop added value revenue streams (e.g., recovery of chemicals)	Variety: o Collaborative agmts o Competitive RFPs with industry	o Cc agm o Cc by F
C. Hydroelectric	1) Micro, small and run of the river hydro technologies are not competitive 2) Existing large scale hydro has adverse impacts on fish	1) Development of : o lower cost technologies o low cost storage 2) Technologies for reducing impacts to fish	Variety: o Collaborative agnts o Competitive RFPs with industry	o Cc agm o Cc by F

Table 3b (continued): Near Term Renewables RD&D: Technology Development Activities

Area	*Issues*	*Focus/Products*	*Funding Mechanism(s)*	
D. Photovoltaic	PV technologies are not cost competitive. Need to focus on niche markets and higher value markets: o PV/roof integrated packages (reducing costs; increasing reliability, power quality; dispatchability) o T&D deferrals o Reductions in manufacturing costs for Calif. applications	Technologies or processes that will help support near term applications of PV in California (e.g., PV/roof; T&D deferrals, etc.). These should focus on: o reduced costs of integrated packages; o emphasis on tangible value beyond electricity; o demonstration of high reliability and power quality; o dispatchability	Variety: o Collaborative agmt o Competitive RFPs with industry	o Cc agm o Cc by F
E. Solar Thermal	Existing technologies not cost competitive. Need to: o reduce O&M o increase capability to economically provide higher value electricty with certainty	Technologies or processes that will help increase the cost competitiveness of solar parabolic trough and power tower technologies.	Variety: o Collaborative agmt o Competitive RFPs with industry	o Cc agm o Cc by F
F. Wind	Existing technologies not cost competitive. Need to: o reduce capital costs o reduce O&M o increase value	Technologies that are lower cost, have lower O&M, have increased capability to supply peak with certainty	Variety: o Collaborative agmt o Competitive RFPs	o Cc agm o Cc by F

B. PIER Renewable Energy RD&D Strategies in the Near, Mid and Long Term

Tables 4a to 4f provide information on near term strategies for helping existing renewable energy technologies become more cost competitive, and on mid to long term strategies for helping develop renewable energy technologies that can provide high public benefits to Californians while being sustainable in California's deregulated electricity marketplace. Near term is defined as the timeframe extending from 1999 to the year 2003. The mid-term timeframe extends up to the year 2007, and the long term timeframe extends to the year 2011. Each table is specific to a renewable energycategory, and indicates the perceived issues confronting development of the technology, the energy RD&D strategies proposed to help resolve the identified issues, and possible funding mechanisms. Funding amounts are shown only for efforts already funded under the PIER program. Proposed funding amounts associated with the strategies identified in the tables will be provided at a later date. However, proposed overall funding levels are presented in Section V of this draft for discussion purposes.

1. Biomass/MSW

Table 4a: Biomass/MSW RD&D Needs and Approaches			
Timeframes/SubArea	***Issues***	***Focus***	***Funding Mech***
1. Existing a. Direct Combustion	Not Competitive: – High Costs – Low efficiencies – Low dispatchability – Lack of understanding of marketplace needs and economics in a deregulated environment – Lack of non electricity revenue streams	*Increase competitiveness in deregulated marketplace by developing techniques or processes that:* – reduce O&M – reduce fuel costs – increase efficiency – increase dispatchability – increase understanding of marketplace needs and economics – develop value added products	PIER Transition, 1 and · High costs: ➢ EER PIER 2 co reducing costs u residues · Dispatchability: ➢ GRI PIER 1 co increasing disp using natural ga existing biomas · Value added produc ➢ Collins Pine PI developing etha value added pro existing biomas **Proposed**: · Tech Assnt: ➢ Updated assessm marketplace econ needs ➢ Strategic value d GIS of biomass distributed gene
2. Near term (2003) a. Direct Combustion	Not Competitive: – High Costs – Low efficiencies – Low dispatchability – Meeting waste disposal needs – Lack of non energy revenue streams	*Continue efforts to increase competitiveness in deregulated marketplace by developing techniques or processes that:* – reduce O&M – increase efficiency – develop value added products – Helps meet waste disposal needs Begin development of new class of direct combustion systems	Collaborative agreement ➢ Begin development efficiency direct co systems that use lo fuels. ➢ Continued develop systems producing products ➢ Demonstration of t processes that lowe scale facilities
3. Mid Term (2007) a. Direct Combustion	Remaining development issues: – High capital costs – Low efficiencies – High emissions compared to natural gas fired systems – Need for high dispatchability	Continued development of direct combustion systems that can compete in a deregulated marketplace: – Highly efficiency and reliable systems – Low capital costs – Low emissions – Integrated w/value added product revenue streams – Strategic value to grid	Various: Collaborative agreement ➢ Development of ne direct combustion (DOE/NREL/indus ➢ Development of int added revenue strea Competitive RFPs: ➢ Development of lo

Table 4a: Biomass/MSW RD&D Needs and Approaches

Timeframes/SubArea	***Issues***	***Focus***	***Funding Mech***
			combustion system
4. Long Term (2011) a. Direct Combustion	Remaining development issues: − High capital costs − Low efficiencies − High emissions compared to natural gas − High dispatchability	*Demonstrating the performance and economics of the high efficiency class direct combustion systems.*	Collaborative agreement ➢ Field tests of new s (DOE/NREL/indus
1. Existing b. Landfill and digestor gas	Not competitive: − High costs − Low efficiencies − Lack of understanding of marketplace needs and economics in a deregulated environment − Lack of non electricity revenue streams	*Increase competitiveness in deregulated marketplace by developing techniques or processes that:* − reduce O&M − increase efficiency − increase understanding of marketplace needs and economics − develop value added products	Nothing to date through **Proposed**: · Tech Assnt: ➢ Updated assessn LGR/biogas faci marketplace econ needs
2. Near Term (2003) b. LGR/Digestor Gas	Not competitive: − High costs − Low efficiencies − Lack of understanding of marketplace needs and economics in a deregulated environment − Lack of non energy revenue streams	*Increase competitiveness in deregulated marketplace by developing techniques or processes that:* − reduce O&M − increase efficiency − increase understanding of marketplace needs and economics − develop value added products	Competitive RFP: ➢ Development of low LGR/biogas systems ➢ High efficiency energ systems for LGR/bic ➢ Development of LGI systems with value a
3. Mid Term (2007) b. LGR/Biogas			
2. Near Term (2003) c. Thermal Gasification	Not competitive: − High costs − Low efficiencies − Unproven performance and economics	Development of competitive thermal gasification systems: − Begin demonstrations of small scale systems that can fill niche markets. − Begin development of higher efficiency systems capable of firing advanced conversion systems	Various: *Competitive RFP:* ➢ Demonstrations of gasification/energy systems to meet nic Cooperative agmt: ➢ Development of hig lower cost gasificat conversion systems

2) Geothermal

Table 4b: Geothermal RD&D Needs and Approaches			
Timeframes/SubArea	***Issues***	***Focus***	***Funding Mecha***
1. Existing geothermal resources and power plants	Not competitive: – High costs – Limited dispatchability – Lack of understanding of marketplace needs and economics in deregulated market – Benefits or true value of avoided costs are not included in the economics of geothermal projects – Lack of non-energy revenue streams	Enhance competitiveness in deregulated marketplace by: – Reduce O&M costs of existing power plants – Reduce costs of drilling and completing geothermal wells – Enhance reservoir management – Develop value-added products and/or minerals recovery – Remove market inequities inhibiting development of geothermal energy. Include a true value of avoided cost of societal damage (emissions) – Develop better understanding of marketplace needs and economics under deregulated environment	PIER Transition, 1 & 2 sol · High costs: ➢ EMI PIER 1 contra test extended data l geothermal explorat **Proposed:** Collaborative agreement ➢ Reduce O&M costs technologies ➢ Reduce drilling cos advanced slimhole develop advanced s diamond drill bits) ➢ Improve reservoir m reduce costs Competitive RFP ➢ Development of va products or mineral zinc, mercury, silic ➢ Improve dispatchab hybrid systems (i.e. geothermal/natural Tech Assnt: · Marketplace assessme
2. Near Term (2003) Drilling, exploration, reservoir engineering and energy conversion	Not competitive: – High costs of: (1) the drilling of exploration, production and injection wells, and (2) plant equipment and construction – Lack of understanding of basic geological conditions associated with hydrothermal systems – Limited dispatchability – Lack of non-energy revenue streams	Continue efforts to enhance competitiveness in deregulated marketplace by developing techniques or processes by: – Lower costs and risks of developing geothermal resources so that existing geothermal fields can be expanded and new geothermal fields can be discovered by: (1) Reducing costs of drilling and completing geothermal wells , (2) Improve understanding of basic geological conditions associated with hydrothermal systems, (3) Enhance reservoir management – Reduce capital and O&M costs of power plants	Collaborative effort: – Develop method or te lower costs and risks geothermal resources technologies for expl detection of fracture a zones, well siting, flu fluid injection and re costs) – Demontrate technique that lower O&M cost – Improve thermodyna of geothermal turbine and lower costs of pla – Develop multiple inc value added products uses of heat

Table 4b: Geothermal RD&D Needs and Approaches			
Timeframes/SubArea	***Issues***	***Focus***	***Funding Mecha***
		– Develop value-added products and other sources of revenues	
3. Mid Term (2007) Drilling, exploration, reservoir engineering and energy conversion	Developmental issues: – High costs of drilling and completing geothermal wells – High costs of plant equipment and construction – Limited dispatchability – Lack of understanding of basic geological conditions associated with hydrothermal systems	Continue development efforts to increase competitiveness of geothermal energy conversion system by: – Reduce costs of drilling and completing geothermal wells – Improve understanding of basic geological conditions associated with hydrothermal systems, and enhance reservoir management – Reduce capital costs & integrate with multiple income sources & value-added products	Collaborative agreements ➢ Develop improved g exploration and dril ➢ Improve basic know nature and occurrenc geothermal reservoi producing energy fr geothermal systems ➢ Develop new genera geothermal turbines improved thermody efficiency and integ multiple income sou costs
4. Long Term (2011)	Remaining development issues: – High costs of locating and producing deeper hydrothermal resources – Need for high dispatchability – Need to develop technology for economically producing energy from enhanced geothermal systems	Pursue development of revolutionary improvements in exploration and drilling technologies Increase accuracy of mapping deep, permeable zones in hydrothermal resources Develop technology to extract energy from resources of progressively lower permeability and fluid content (heat mining,	Collaborative: ➢ Revolutionary impr geothermal explorat drilling techniques ➢ Develop method or increase accuracy of permeable zones in resources Competitive RFP: ➢ Develop and demon technology to extrac resources of progres

Table 4b: Geothermal RD&D Needs and Approaches

Timeframes/SubArea	*Issues*	*Focus*	*Funding Mecha*
		HDR) Demonstrate new generation of geothermal turbines with improved thermodynamic efficiency and lower costs	permeability and flu (heat mining, HDR) ➢ Demonstrate new ge geothermal turbines improved thermody efficiency and lower

3) Hydroelectric

Table 4c: Hydroelectic RD&D Needs and Approaches

(not available for this draft)

4) Photovoltaics

Table 4d: PV RD&D Needs and Approaches			
Timeframes/SubArea	***Issues***	***Focus***	***Funding Mechan***
5) Existing 6) Residential and Commercial (assumes crystalline silicon PV flat plate systems at present)	Not competitive: - High costs - Lack of integration - Power quality - Dispatchability - Non energy benefits - Lack of understanding of market needs in deregulated marketplace - Insufficient solar resource information on needed for reliable PV roof and building integrated applications	Increase competitiveness in niche markets based on other than just electricity: - reduce manufacturing costs - increase integration - increase power quality - develop non energy benefits - develop understanding of residential and commercial market needs and economics for PV - conduct resource assessments needed to support PV roof and building integrated applications	PIER Transition, 1 & 2 soli · High costs: ➢ UPG PIER 1 contr manufacturing cost ➢ PowerLight PIER 1 reducing man. Cos ➢ SCE Transition co standardization of s components · Integration: ➢ SDG&E Transition chargeport · Power quality: ➢ SMUD: improving conditioning · Non energy benefits: ➢ PowerLight contra
5) Existing b. Industrial and Utility	Not competitive: - High costs - Lack of integration - Power quality - Non energy benefits - Lack of understanding of market needs in deregulated marketplace - Insufficient solar resource information on needed for reliable PV roof and building integrated applications	Increase competitiveness in niche markets based on other than just electricity: - reduce manufacturing costs - increase integration - increase power quality - develop non energy benefits - develop understanding of industry market needs and economics for PV	PIER Transition, 1 & 2 soli · Dispatchability: ➢ EDTEK PIER 1 co solar fossil to incre & dispatchability
5) Near term (2003) 6) Residential and Commercial	Provide higher value to customers: - Value beyond offset electricity - Reliability - Ease of installation - Lower costs	Increase value of systems: - Higher non energy benefits - High reliability - Easy to install - Lower installed costs	Various: · Tech Assnt ➢ Assessment of marl needs and economi ➢ Resource assessme ➢ Quantifying benefi deregulated enviror · Collaborative Agmt

Table 4d: PV RD&D Needs and Approaches			
Timeframes/SubArea	***Issues***	***Focus***	***Funding Mechan***
			➢ Performance qualit & improvement ➢ Installation quality improvement · Competitive RFPs: ➢ Reducing installati ➢ Reducing BOS cos ➢ Standardization of

5) Solar Thermal Electric

Table 4e: Solar Thermal Electric RD&D Needs and Approaches

(not available for this draft)

6) Wind

Table 4f: Wind RD&D Needs and Approaches			
Timeframes/SubArea	***Issues***	***Focus***	***Funding Mechan***
1. Existing a. Utility scale systems	Not competitive: – High costs – Not dispatchable – Lack low cost storage – Avian mortality issues – Lack of understanding of marketplace needs and economics in deregulated market – Lack of understanding of strategic value of wind in grid – Inability to forecast wind resources – Lack of integration in the overall grid	Increase competitiveness by: – Reducing O&M – Develop forecasting models – Develop better understanding of marketplace needs and economics under deregulated environment – Reducing avain mortality (should be addressed in Environmental area)	PIER Transition, 1 & 2 soli · High costs: ➢ WTC PIER 1 contrac developing a low cos **Proposed:** · Tech assnt: ➢ Marketplace assessm ➢ Strategic value to gri and GIS analyses · Collaborative agreemen ➢ Forecasting models (
2. Near Term (2003) a. Utility scale systems	Emerging competitive: – Costs still too high to be competitive in open market – Not dispatchable – Lack of grid integration	Develop low cost turbines that can begin to compete in the open market: · Continue development of advanced, low cost turbine · Begin development of low cost storage	Variety · Collaborative agreemen ➢ Development of low (DOE/NREL/industr · Competitive RFP ➢ Development of low for utiltiy scale winc
3. Mid Term (2007) a. Utility scale systems	Open competitive issues: – Lowering manufacturing costs – Prove performance – Complete integration and hybridization – Demonstrate dispatchability	Demonstrate performance of prototype low cost turbine, begin lowering manufacturing costs, and begin integration into grid by: · Demonstrating prototypes · Development of lower cost manufacturing techniques · Field test dispatachbility	Variety: · Collaborative agreemen ➢ Obtain performance c prototypes ➢ Field tests on dispat using forecasting mo prototypes · Competitive RFPs ➢ Develop lower cost manufacturing techniqu
4. Long Term (2011) a. Utility scale systems			
1. Existing *a. Small scale systems (<40kw)*	Not cost effective: – High costs – Lack of standardized interconnection equipment – Difficult to integrate with hybrid resources	Increase competitveness – Develop better resource assessment for small scale systems	Nothing done to date under **Proposed:** · Competitive RFP: ➢ Extension of DOE w

Table 4f: Wind RD&D Needs and Approaches			
Timeframes/SubArea	***Issues***	***Focus***	***Funding Mechan***
	– Low reliability of power conditioning systems – Need for high reliability and low O&M – Needs ease of installation – Resource assessment for small scale systems		to 1 km grid
2. Near Term (2003) b. Small scale systems (<40kw)	Not cost effective: – High costs – Difficult to integrate with hybrid resources – Low reliability of power conditioning systems – Need for high reliability and low O&M – Needs ease of installation	Increase competitiveness by: – Begin development of low cost, high reliability turbines with low O&M – Develop low cost storage	Competitive RFPs: ➢ Development of low relability turbines ➢ Development of low and high reliability F be developed under S
3. Mid Term (2007) *b. Small scale systems (<40kw)*	Emerging cost effective: – Control systems that allow integration with variety of hybrid resources – Lack of standardized interconnection equipment – Lack of performance data on prototypes	Continue development of small scale systems that are cost effective to users by: – Developing control systems that allow integration as a hybrid – Develop standardized interconnection equipment – Obtain performance data on prototypes	Competitive RFPs: ➢ Develop control syst ➢ Development of stan interconnection equi ➢ Conduct field tests
4. Long Term (2011) b. Small scale systems (<40kw)			

C. Targets for Renewable Energy RD&D Work Under PIER

Overall goals were prepared to provide a vision of what California's renewable energy technologies should look like in the future. To assist in achieving these overall goals, PIER funding will be directed at specific areas using targets. PIER funding is intended to fill RD&D gaps that are impeding further development of a renewable energy technology that will provide important benefits to Californians. Renewable energy tends to be very technology dependent. For example, the issues and means of resolving issues specific to photovoltaic systems tend to be very different than for biomass direct combustion systems, which in turn are different than for solar thermal electric systems. For this reason, CEC staff have prepared near term targets for renewable energy RD&D work under PIER that, while they address the overall goals, are broken out by technology areas (for this draft only the biomass near term goals have been prepared as an example).

1) Biomass/MSW

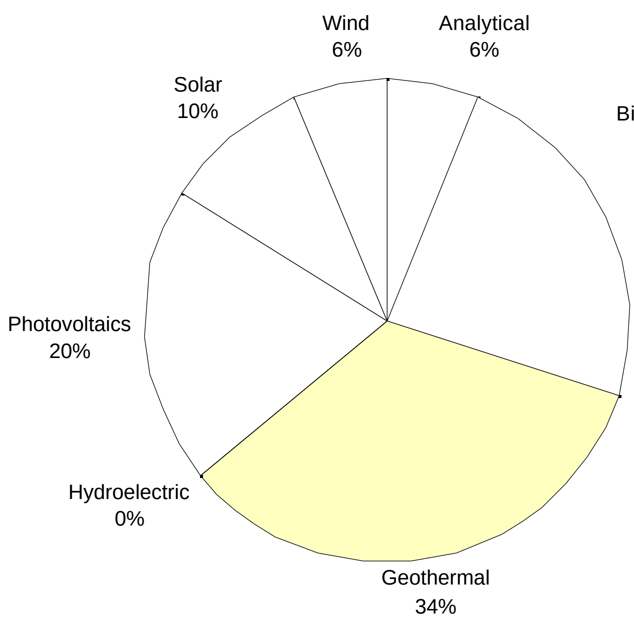
Table 5a: Near Term PIER RD&D Goals for Biomass/MSW

Technology Area	*Target Area*	*Overall Goal(s)*	*Possible Technical Area(s)*
Biomass: Direct Combustion	1. Reduce Costs	1. COE of less than \$0.04/kwhr by 2003 without subsidies	a. Reduce fuel costs to less than \$10/ton FOB the plant b. Reduce O&M costs to less than \$0.01/kwhr
	2. Improve Dispatchability	2. Capability to supply peak and intermediate energy on demand and at less than 10% cost increase	a. Hybridization b. Low Cost Storage
Biomass: Landfill Gas to Energy and Biogas Systems	1. Reduce Costs	1. COE of less than \$0.04/kwhr by 2003 without subsidies	a. Reduce gas collection and energy conversion system costs

D. Overview of Proposed Renewables RD&D Funding

Although project specific funding levels will be provided at a later date, overall proposed funding amounts specified at the technology level are provided in this draft for discussion purposes. Figure 4a provides breakout of the proposed funding levels by technology type for fiscal year 1998/99. Figure 4b 4a provides breakout of the proposed funding levels by technology type for fiscal year 1999/2000 (Please note that the Energy Commission uses a fiscal year beginning on July 1, and ending the following June 30th). Currently, there is no proposed funding shown for hydroelectric technologies. However, once CEC staff have a better understanding of the role of hydroelectric technologies in a derregulated marketplace, and the likely impacts of turbine advancements, the proposed funding levels for hydroelectric are likely to be adjusted.

Figure 4a: Proposed PIER Renewables RD&D Funding FY 98/99

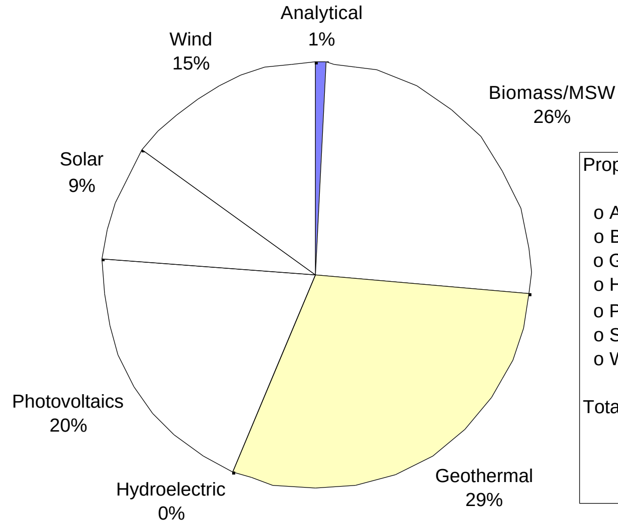


Proposed PIER Funding FY 98/99:

- o Analytical: $300,000
- o Biomass/MSW: $1.2 million
- o Geothermal: $1.7 million
- o Hydroelectric: NA
- o Photovoltaics: $1 million
- o Solar: $500,000
- o Wind: $300,000

Total: $5 million

Figure 4b: Proposed PIER Renewables RD&D Funding FY 99/00



Proposed PIER Funding FY 99/00:

- Analytical: $120,000
- Biomass/MSW: $4.3 million
- Geothermal: $5 million
- Hydroelectric: NA
- Photovoltaics: $3.3 million
- Solar: $1.5 million
- Wind: $2.5 million

Total: $17.7 million